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MIDDLETOWN, OHIO

~~ENGINEERING REPORT NO. 741 (AGN-123)~~ ER-741 OTS: $2.60ph, $1.04mf

RESEARCH AND DEVELOPMENT OF S-1C HEAT SHIELD PANELS

OTS

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For
George C. Marshall Space Flight Center
NASA-Huntsville, Alabama
NASA Contract NAS8-5221
Monthly Report No. 9, Oct. 1963

~~OCTOBER, 1963~~

PREPARED BY D. Y. Potter CHECKED BY ______

author D. Y. POTTER, PROJECT ENGINEER

COMPLETED NOVEMBER 14, 1963 28p APPROVED BY C. J. Giemza

C. J. GIEMZA, CHIEF ENGR.
STRUCTURES & MATERIALS RESEARCH

REVISIONS

LET.	DATE	BY	NO. PAGES	CHANGES	PAGES AFFECTED

ORIGINAL NO PAGES

N64-13316

INTRODUCTION

This report by Aeronca Manufacturing Corporation to the George C. Marshall Space Flight Center, NASA-Huntsville, Alabama, covers the work accomplished on Contract NAS8-5221 for the ninth calendar month of the program, October 1963.

The following items are included:

1. Total Engineering hours expended during October were 381.
2. Metal to Metal Heat Shield Panel Braze Quality on Contract NAS8-6976.
3. Analysis of Metal to Metal and Core to Metal Braze Voids for the 30M12571 Heat Shield Panel.
4. Repair Procedures.
5. Deflection characteristics of M-31 Insulation.

REVISIONS

HEAT SHIELD PANEL BRAZE QUALITY
METAL TO METAL AND CORE TO METAL AREAS

Braze discrepancies with respect to metal to metal and core to metal (shear ties) defects are shown in Figures 1 through 6 for all of the heat shield panels produced on Contract NAS8-6976. The extent of metal to metal or faying surface voids (FSV) for these panels expressed as percentage of the total metal to metal braze areas varies from .26% ($\frac{1.7}{620}$) for panel No. 3 (Fig. 4) to 3% ($\frac{19}{620}$) for panel No. 5 and 4% ($\frac{25}{620}$) for panel No. 2 which exhibited the largest metal to metal void area. Only one panel (No. 4) showed any core to metal defect which consisted of light fillets between the core and the vertical leg of the zee section edge member. As such, this condition would be acceptable; however, the panel was scrapped for other reasons (excessive core to facing voids). The analysis for the effect of such braze discrepancies is given in the following section.

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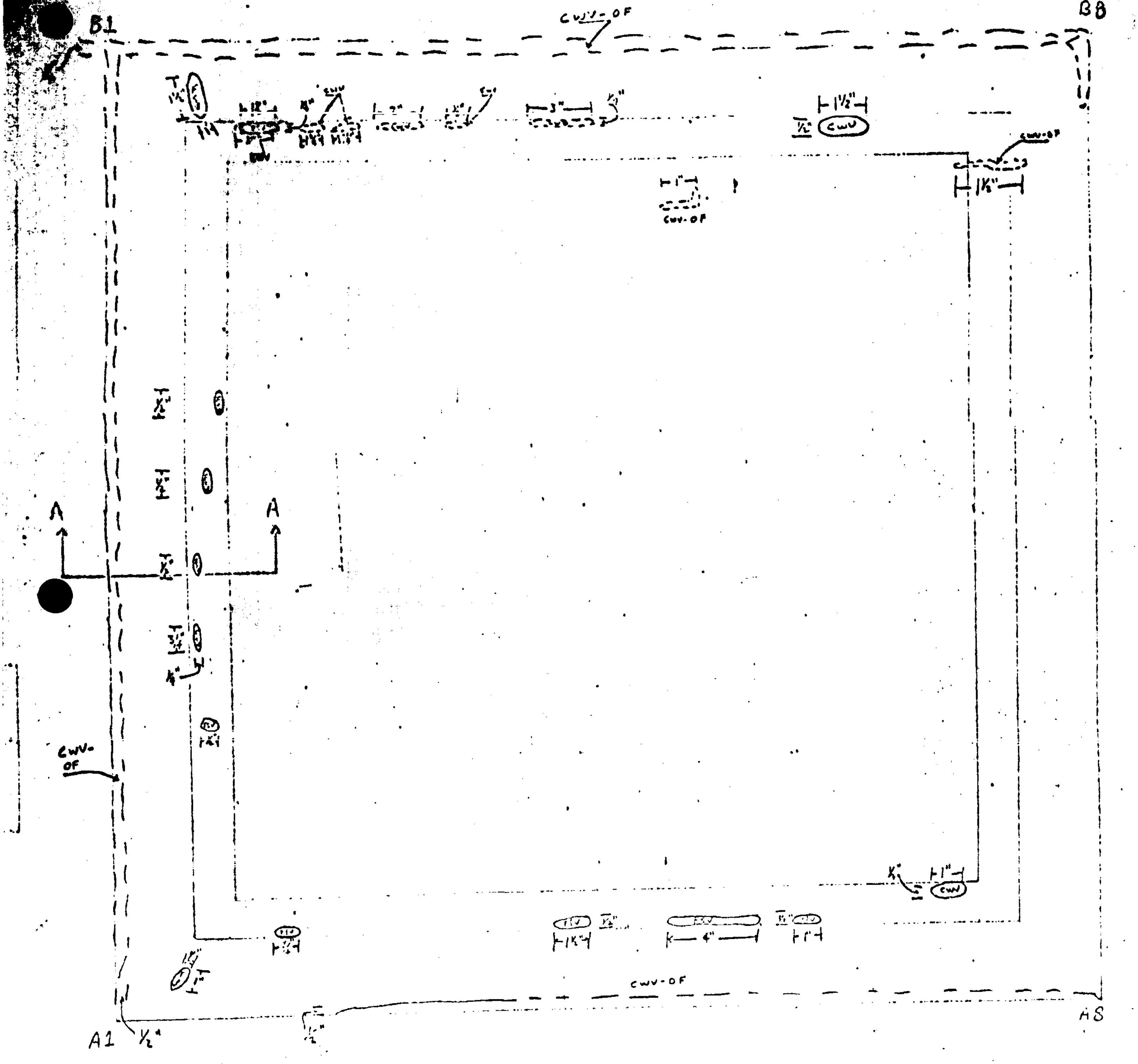
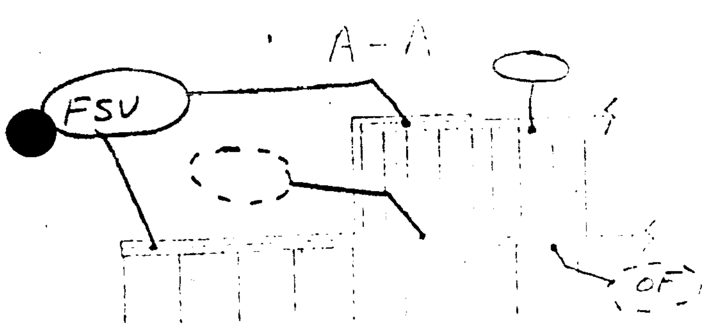




PART No. 14-1 DATE 3-7-63

S/N 1 X-Ray No. B2689

Prepared by D. HAYES

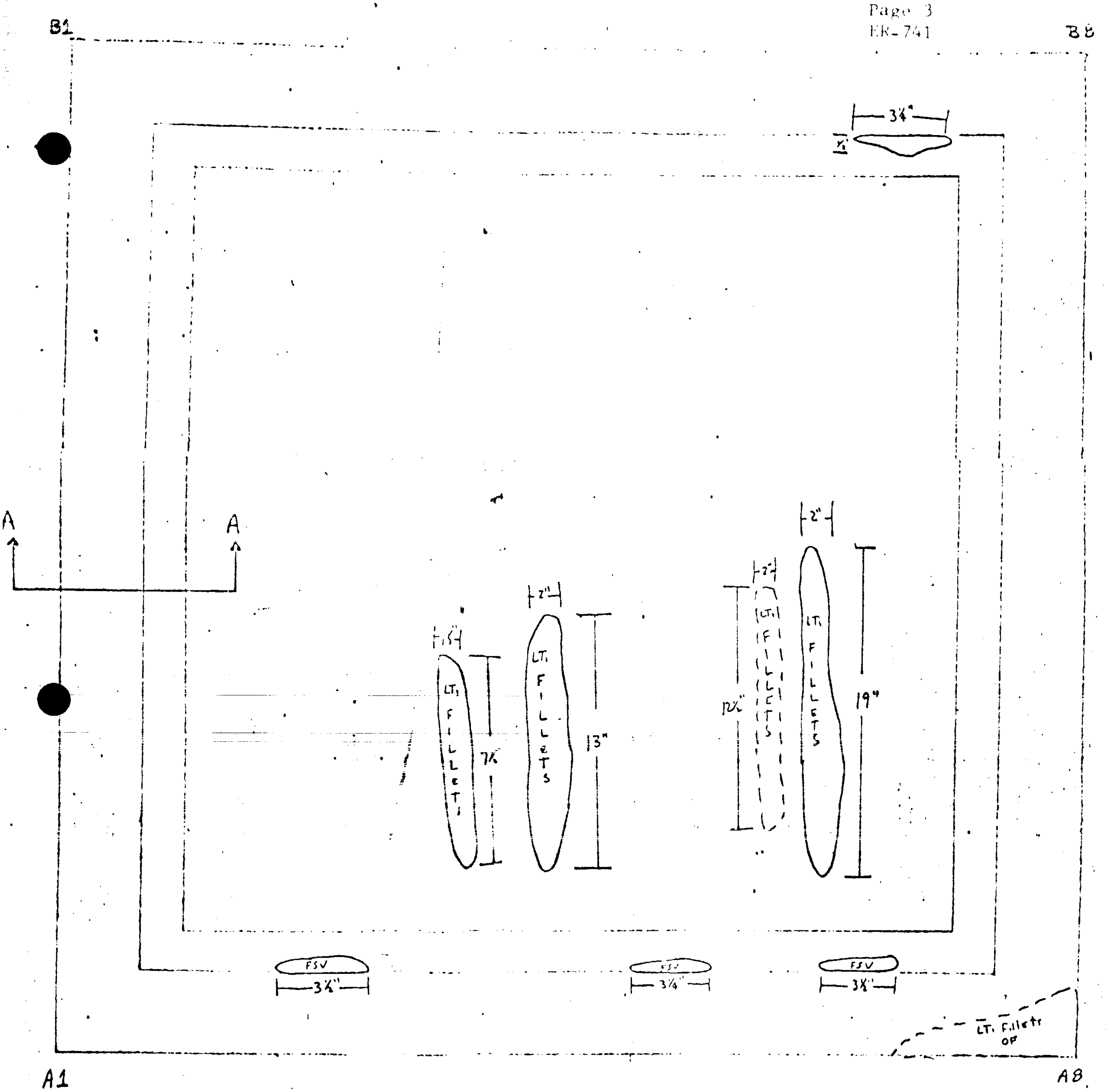
AVG. FILLET SIZE:

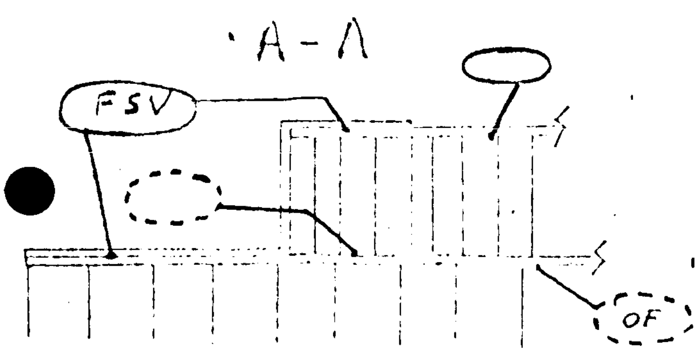
.020

.025

NODE FLOW CONDITION 100%

Figure 1





PART No. 14-1 DATE 4-29-63

S/N S/R 1 X-RAY No. B 2785

PREPARED BY D HAYES

AVG. FILLET SIZE:

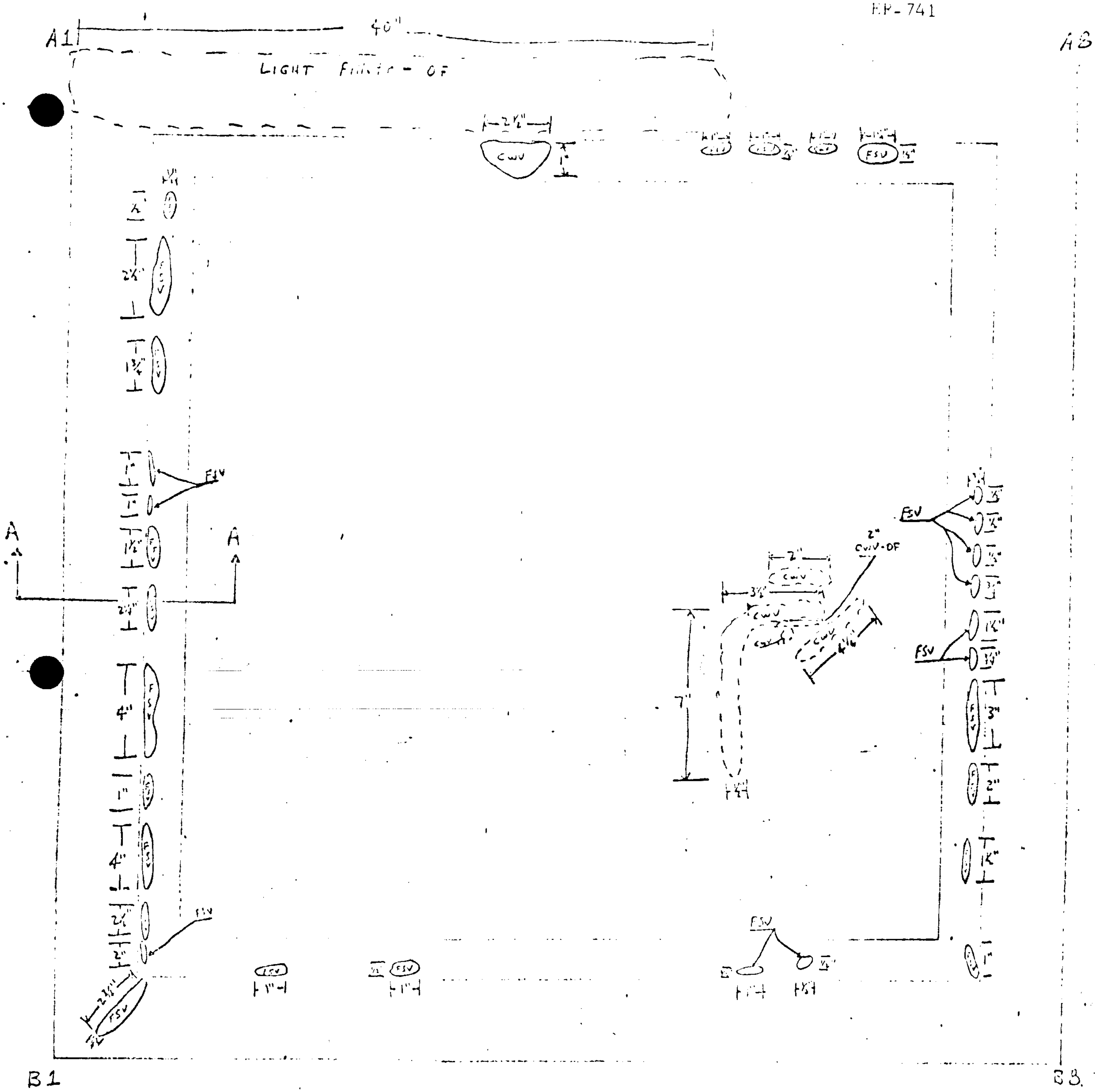
INTERNAL CORE .015

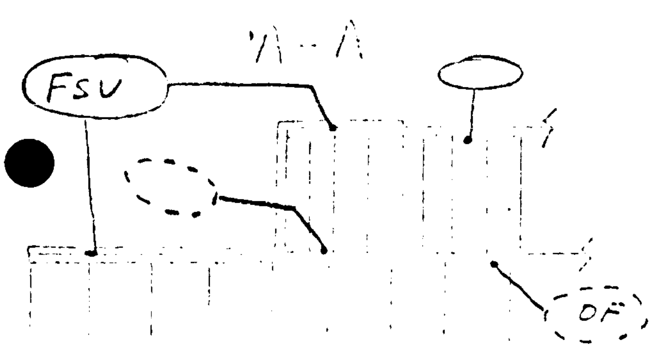
EXTERNAL CORE .025

NODE FLOW CONDITION

100%

Figure 2





Part No. 14-1

S/N 2

Date 3-10-63

Dwg No. B2694

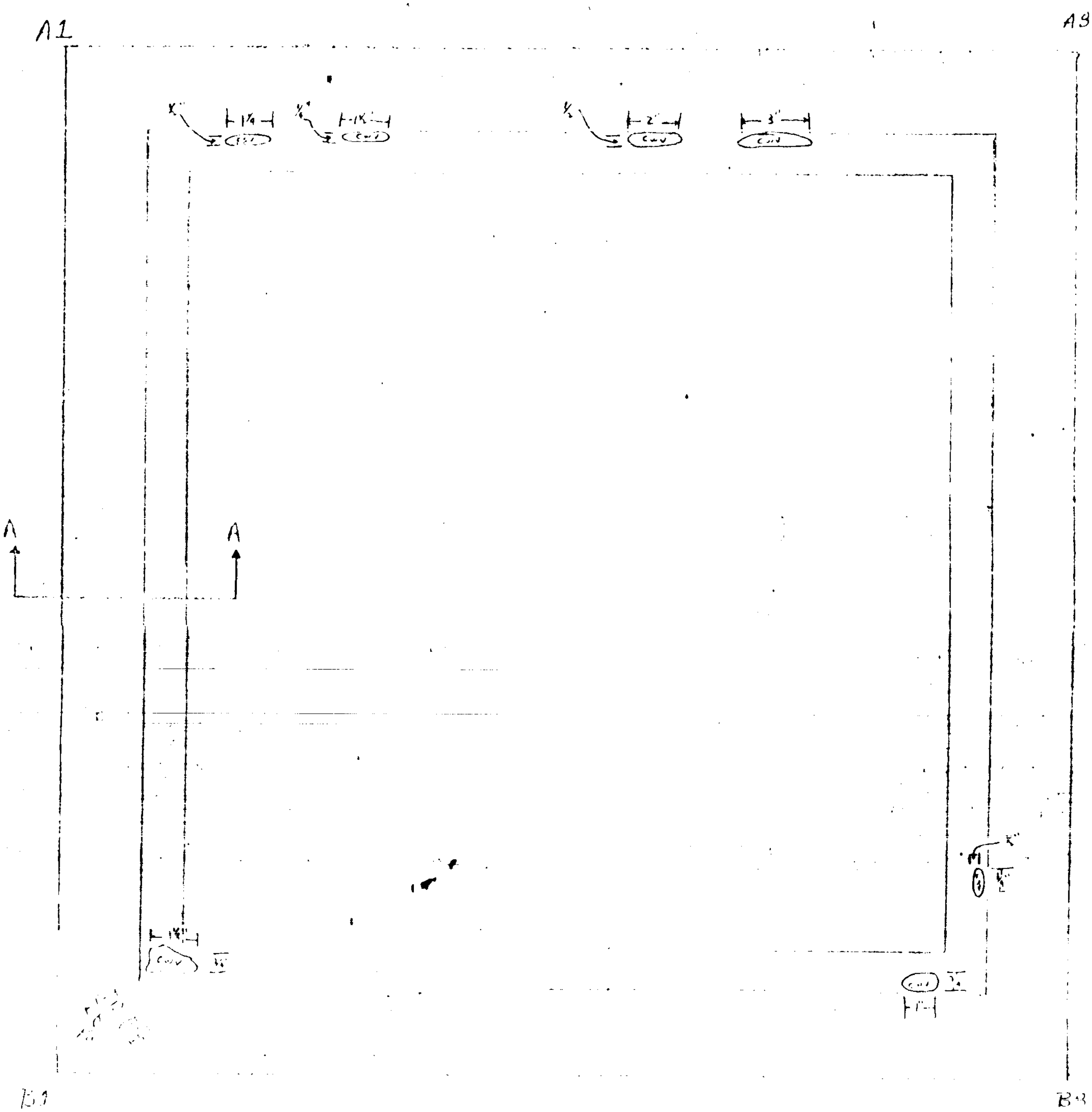
D. Hayes

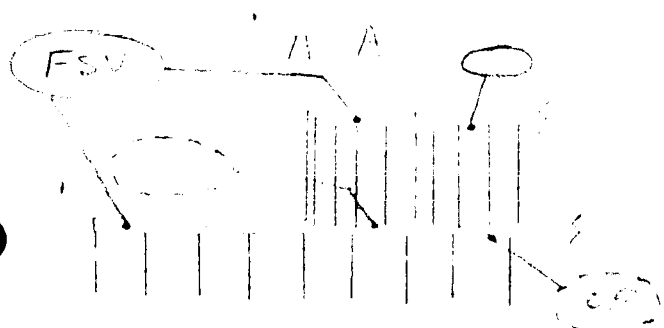
.020

.025

Node Flow Condition:
100%

Figure 3





11-1 3-18-63

3 B2700

D. Hayes

AVG. FILLET SIZE:

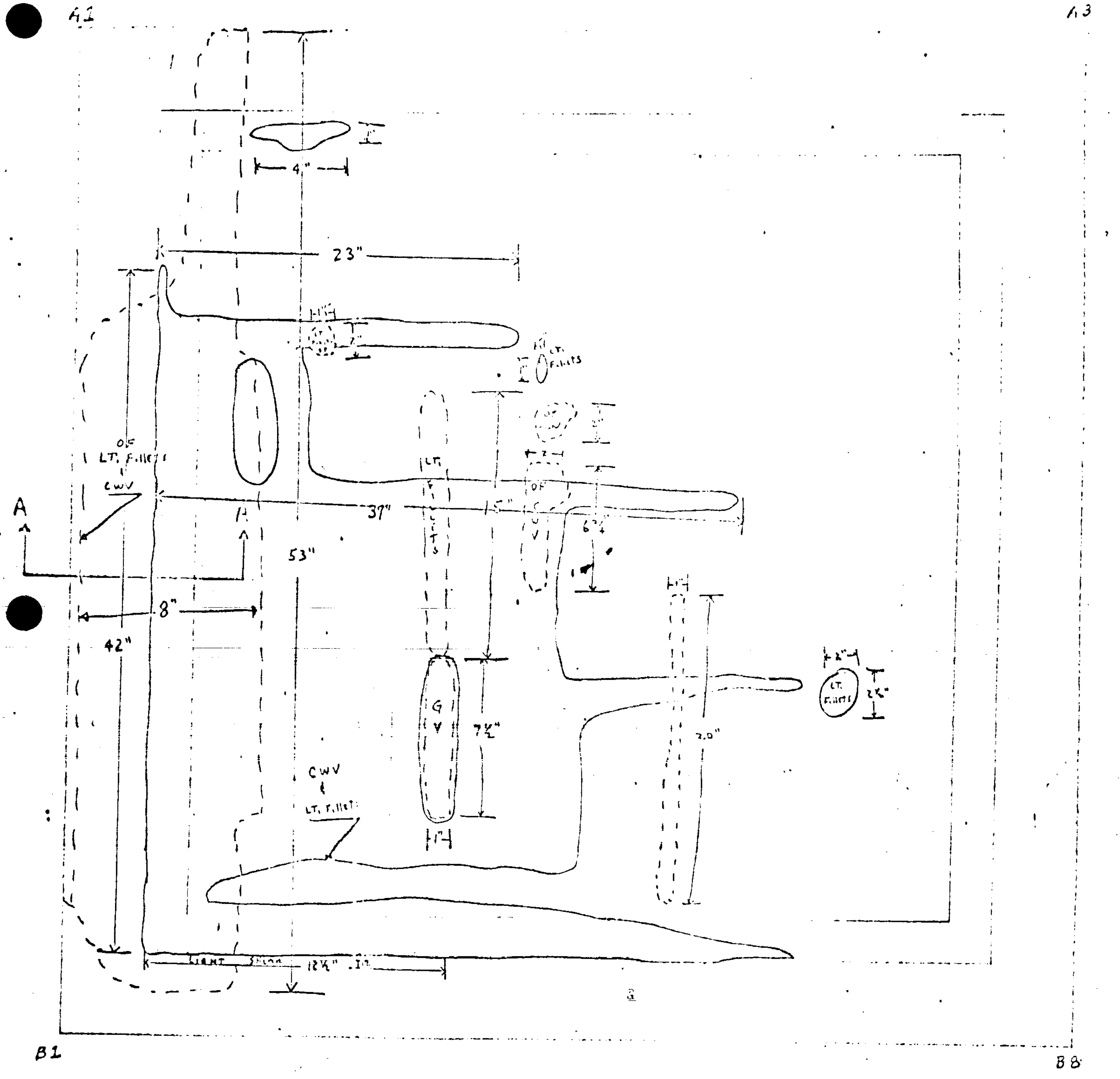
INTERNAL CORE .015

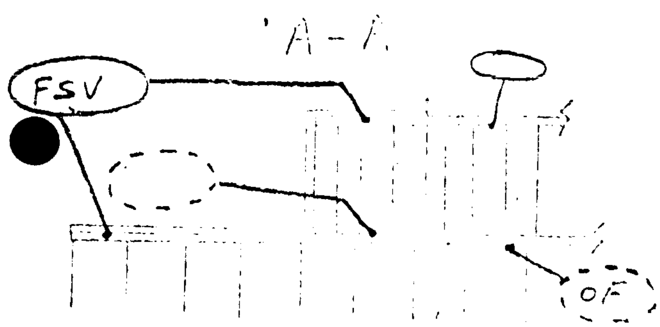
EXTERNAL CORE .030

NODE FLOW CONDITION;

100%

Figure 4





Part No. 14-1 Date 3-21-63

S/N 4 X-ray No. B 2705

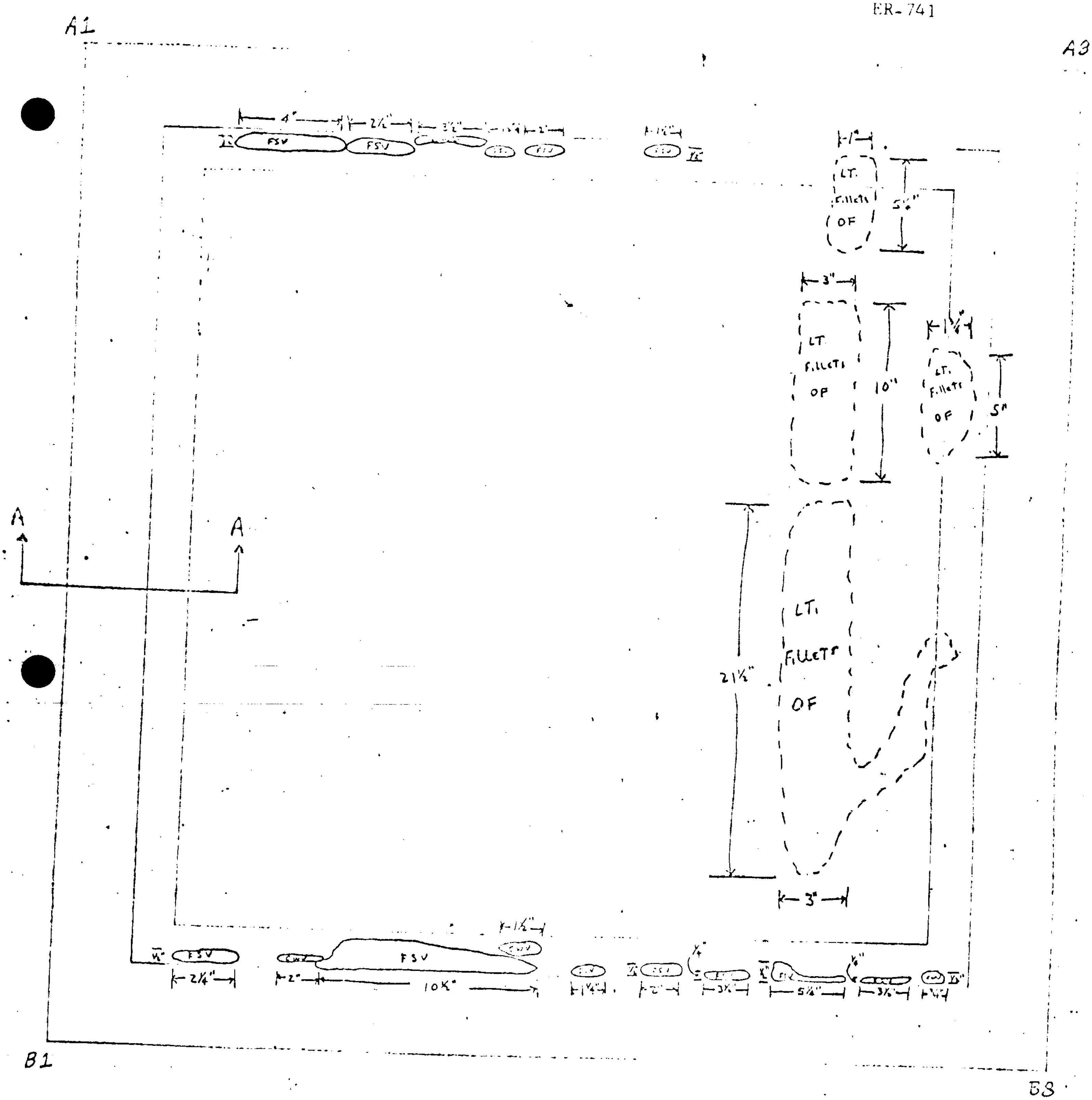
By D. Hayes

Avg. Fillet Size: Node Flow Condition:

Internal Core .015 100%

External Core .015 Panel Scrapped

Figure 5



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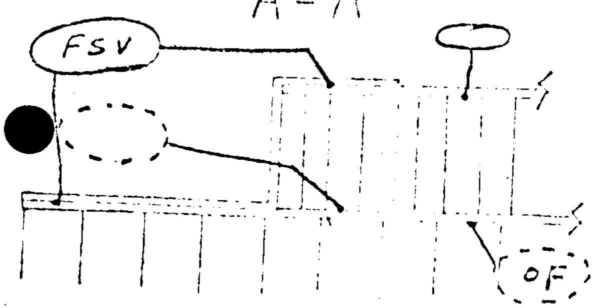


PART No. 14-1 DATE 3-26-63

S/N 5 X-Ray No. B 2712

Prepared D. Hayes

AVG. ... SIZE:

INTERNAL ... .015

EXTERNAL ... .030

NODE Flaw Correlation 100%

Figure 6

ANALYSIS OF METAL TO METAL AND CORE TO METAL VOIDS IN 30M12571 HEAT SHIELD PANEL

Core to Metal Voids

The core to metal joint is assumed to carry the entire load. Since the vertical leg of the Zee is 1" the total shear area for the panel is 4a sq. in. where a is the length of the core (48.3 in.). The shear load per inch of perimeter then becomes $\frac{qa^2}{4a}$ or $\frac{qa}{4}$ psi of wall area. The core to metal attachment area for Type 4-15 core per square inch of surface would be 4 x .005 = .020 in^2 of shear area*. The shear stress on the braze attachment is:

$$f_s = \frac{qa}{4 \times .02} = \frac{48.3\ q}{.08} = 603q \text{ psi}$$

The shear strength allowable for the silver-copper-lithium braze alloy is 15,000 psi at RT and 12,750 at 500° F (Ref: Convair Spec. FZS-4-162A).

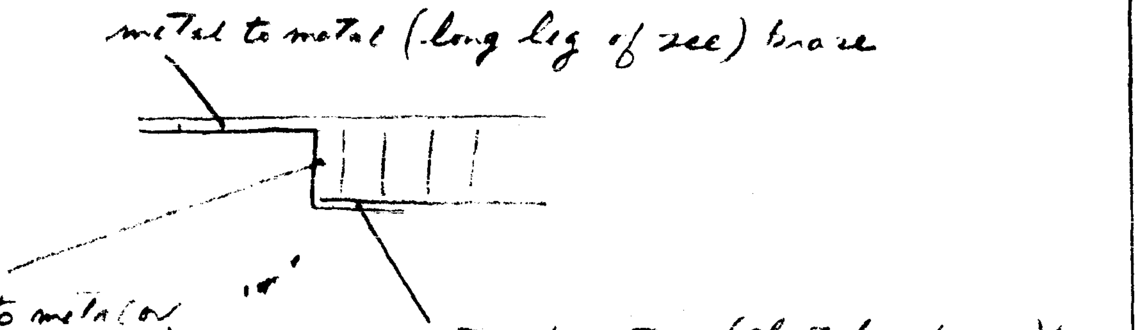
For q = 2.7 air load plus 0.72 psi dynamic load (noise and vibration)

q = 1.0 air load plus 0.72 psi dynamic load (noise and vibration)

f_s = 2050 and 1025 psi respectively

Thus for the worst condition the maximum void allowable is

$$1 - \frac{2050}{15000} \times 100 = 85\%$$



* Core to metal or shear tie braze .005" light fillet

Metal to Metal Voids - Short Leg of Zee Member

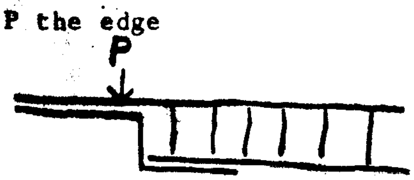
Assume the short leg of the zee must carry the entire panel load as a tensile loading on the facing to short leg zee braze. The width of this braze area is 0.875 and the total braze area is 4a - 3.5 (a = 48.3). The panel load is qa^2 with the tensile stress in the braze given by

$$\frac{qa^2}{4a - 3.5} = 12.3q$$

. Applying the worst loading condition $q = (2.7 + 0.72) = 3.42$ psi. The stress in the braze is 42 psi. The braze tensile allowable is approximately 25,000 psi, $\left(\frac{15000}{.6}\right)$ consequently a very large margin is present for this loading condition.

Metal to Metal Voids - Long Leg of Zee Member

When the composite edge member (long leg of zee) and facing is bent by a shear load at point P the edge



rotation is given by:

$$\theta = \frac{PL^2}{2EI} = \frac{ML}{2EI} = \frac{41.4 \times (.897)^2}{2 \times 29 \times 10^6 \times 1.84} = .03125 \text{ radians}$$

Where $P = \frac{1}{4}\, aq$ lbs/inch

$a = 48.3$

$q = (2.7 + 0.72) = 3.42$ psi

The stress in the braze is:

$$f = \frac{MC}{I} \quad \text{where } M = \frac{2EI\theta}{L}$$

$$f = \frac{2E\theta C}{L} = \frac{2 \times 10.2 \times 10^6 \times .03125 \times .019}{.897} = 13,500 \text{ psi}$$

Since the braze must withstand the shearing force resulting from the bending the 13,500 psi value may be compared with the braze shear allowable namely 15,000 psi. Actual values however for the silver-copper-lithium braze alloy are 19,600 psi (RT) (Ref: Convair Spec. FMS0036).

With the panel edge secured by means of bolts to the support beam flanges the principal concern with voids between the facing and zee occurs when the facing experiences a compression loading resulting from bending of the .06" thick composite edge member (flight condition loading). As a result the facing would tend to buckle in unbrazed areas so that voids might propagate into the core to facing areas, particularly, if core to facing voids near the edge members were present. Where no core to facing voids near the panel edge are present, metal to metal void propagation is unlikely since the panel edge rotation is very small. As a consequence, the compressive forces required for extensive buckling in metal to metal voided areas will not be produced.

REPAIR METHODS FOR METAL TO METAL VOIDS

Repair methods applicable to metal to metal braze voids include:

a. Mechanical Fasteners--Either blind or countersunk rivet fasteners depending on the void location and interference requirements may be used. A recommended fastener is the DuPont Aircraft Blind Expansion Rivet (PN Series) of low carbon nickel alloy. This fastener is available with either a modified brazier head or 100% flush head. Expansion of the rivet shank is accomplished by applying a heated tool to the rivet head which activates the sealed internal chemical charge. This type of rivet has been widely used for applicable brazed panel repairs with complete success. Certain NASA test panels produced on Contract NAS8-6976 were repaired using this type rivet, as shown in Figure 7 . Repairs to voids in either the short or long leg of zee member can be readily accomplished with this fastening system both in the field as well as by the panel fabricator.

b. Spot Welds--This joining method has been used for metal to metal repairs where the area to be repaired is accessible; i.e., the long leg of the zee and the faying surfaces are sufficiently clean (unoxidized) so a sound nugget can be formed. As a consequence, this method is limited with respect to void location and equipment availability.

c. Fusion Welding--Applicable to metal to metal voids between long leg of zee and facing that extend the full width (edge to edge). Essentially a burndown weld is performed which joins the facing and edge member. The presence of silver brazing alloy in the fusion zone is not detrimental to the joint; however, it does cause some difficulty because of the tendency to "blow out". Consequently, a complete void condition is preferred for this type of repair.

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REPAIR METHODS FOR CORE TO METAL (SHEAR TIE) VOIDS

Repair for core to metal or shear tie voids consists of injection of a foam type adhesive through holes drilled in the vertical leg of the zee, curing the adhesive and plugging the drilled holes with a sealer or potting compound.

The detail requirements are:

a. Clean surface (MEK) and lay out hole pattern using 1.0" hole spacing and drill holes (No. 50 drill).

b. Inject via a lever type gun Thermo-Foam 607, Type I (Hexcel Products). Cover holes with one layer masking tape, reopen holes and add another layer of type over same area (no holes). This provides an expansion area for the adhesive to flow into during the curing.

c. Attach thermocouple(s) to the area to be repaired and cure in oven at:

180°-190° F for 25-30 min. followed by
225°-240° F for 50-60 min. followed by
325°-350° F for 25-30 min.

d. Reopen holes used for injection to a depth of approximately 0.1" and seal with Silastic RTV.

BRAZE QUALITY STANDARDS
FOR METAL TO METAL AND CORE TO METAL JOINTS

The maximum sizes of metal to metal and core to metal braze voids recommended for acceptance "as is" are given in Table . These size and spacing requirements are based on empirical standards modified for the S-1C heat shield panel requirements.

TABLE 1

METAL TO METAL AND CORE TO METAL BRAZE REQUIREMENTS

Metal to Metal (faying surface void)	The voided area shall not exceed 25% of the joint area for each lineal inch of braze joint. A metal to metal void shall not be continuous from edge to edge.
Core to Metal (shear tie void)	Any vertical shear tie 50% or more brazed is acceptable. The maximum number of unbrazed or completely void shear ties shall be not more than 3 in any 5 consecutive shear ties.

REVISIONS:

DEFLECTION CHARACTERISTICS OF M-31 INSULATION WITH STAINLESS STEEL HONEYCOMB REINFORCEMENT

An important consideration in the use of ceramic materials for heat shield panel applications is the deflection allowable; i.e., the amount of bending the composite panel can withstand before failure of the ceramic occurs from the resultant tensile stress. The deflection characteristics of M-31 were recently determined by Aeronca as part of the S-1B heat shield panel program (Contract NAS8-4016) and are included as pertinent design information.

The test arrangement employed, shown in Figures 8 and 9, utilized a 3"x15" specimen with two point loading. Specimen configuration was a 1.02" thick load bearing panel with 0.250" thick 8-15 open faced core deformed to about 0.2" in height, M-31 thickness was 0.3". The test data is given in Table 2.

The radius of curvature for the deflection at which failure occurred may be calculated by

$$R = \frac{\left(\frac{C}{2}\right)^2}{2H} \quad \text{where } C = \text{chord length}, \; H = \text{deflection}$$

$$R = \frac{\left(\frac{7}{2}\right)^2}{.029} = 418 \text{ inches}$$

For the 30M12571 panel using the ½" deflection allowable, the corresponding radius of curvature is:

$$R = \frac{\left(\frac{48.3}{2}\right)^2}{1} = 583 \text{ inches}$$

REVISIONS:

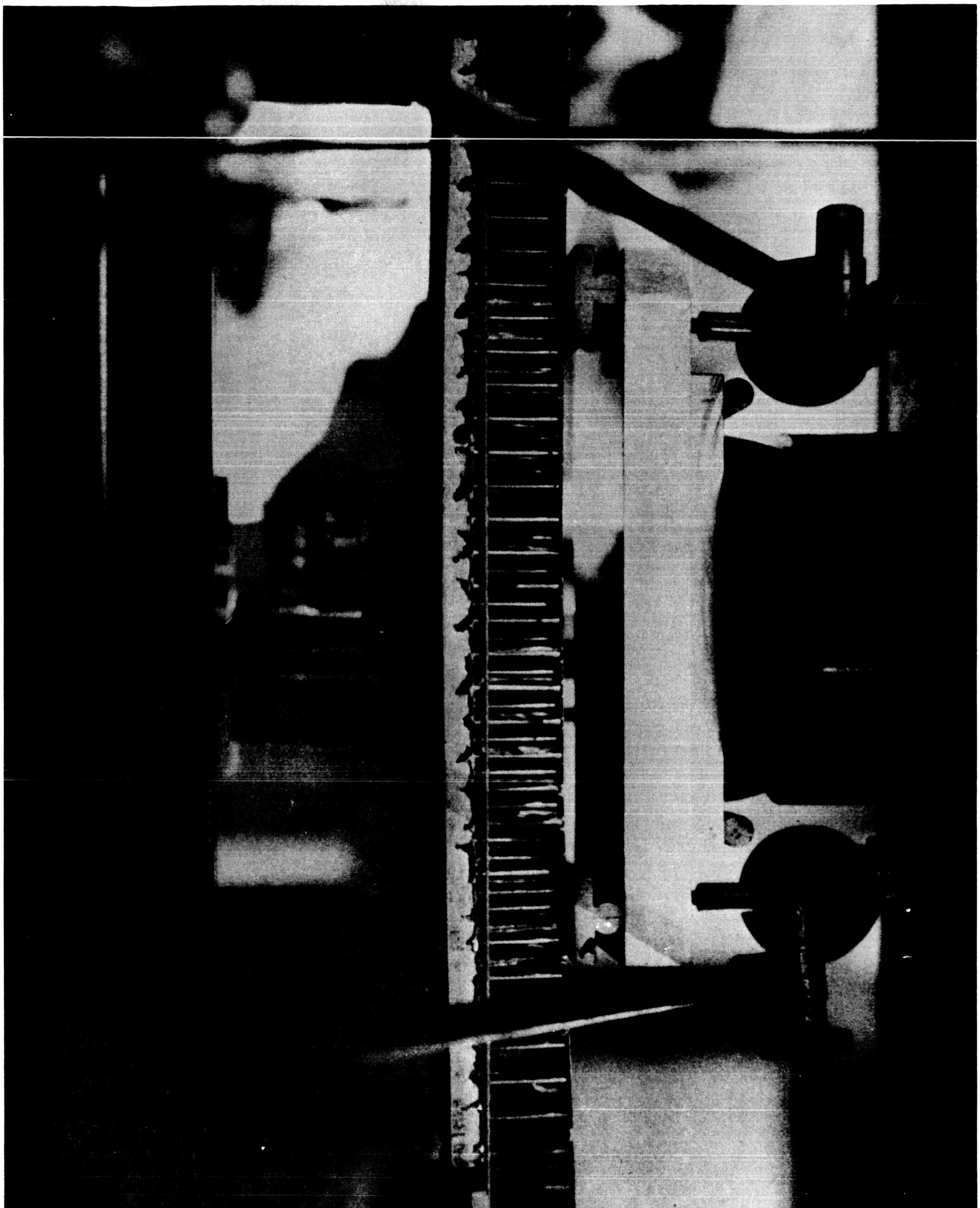
Therefore, the safety factor with regard to the deflection produced cracking of the M-31 is approximately $\frac{583}{418}$ or 1.38.

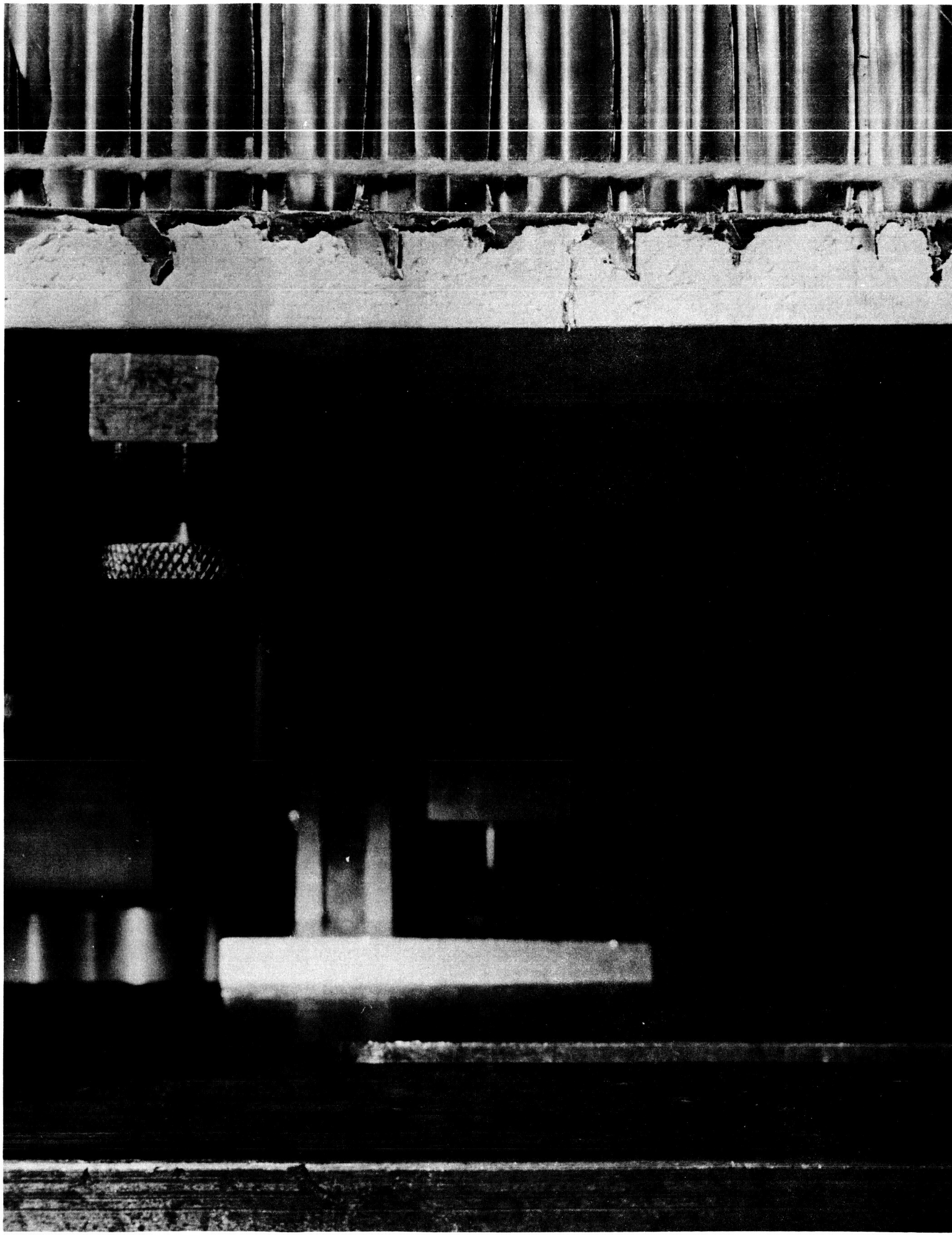
TABLE 2

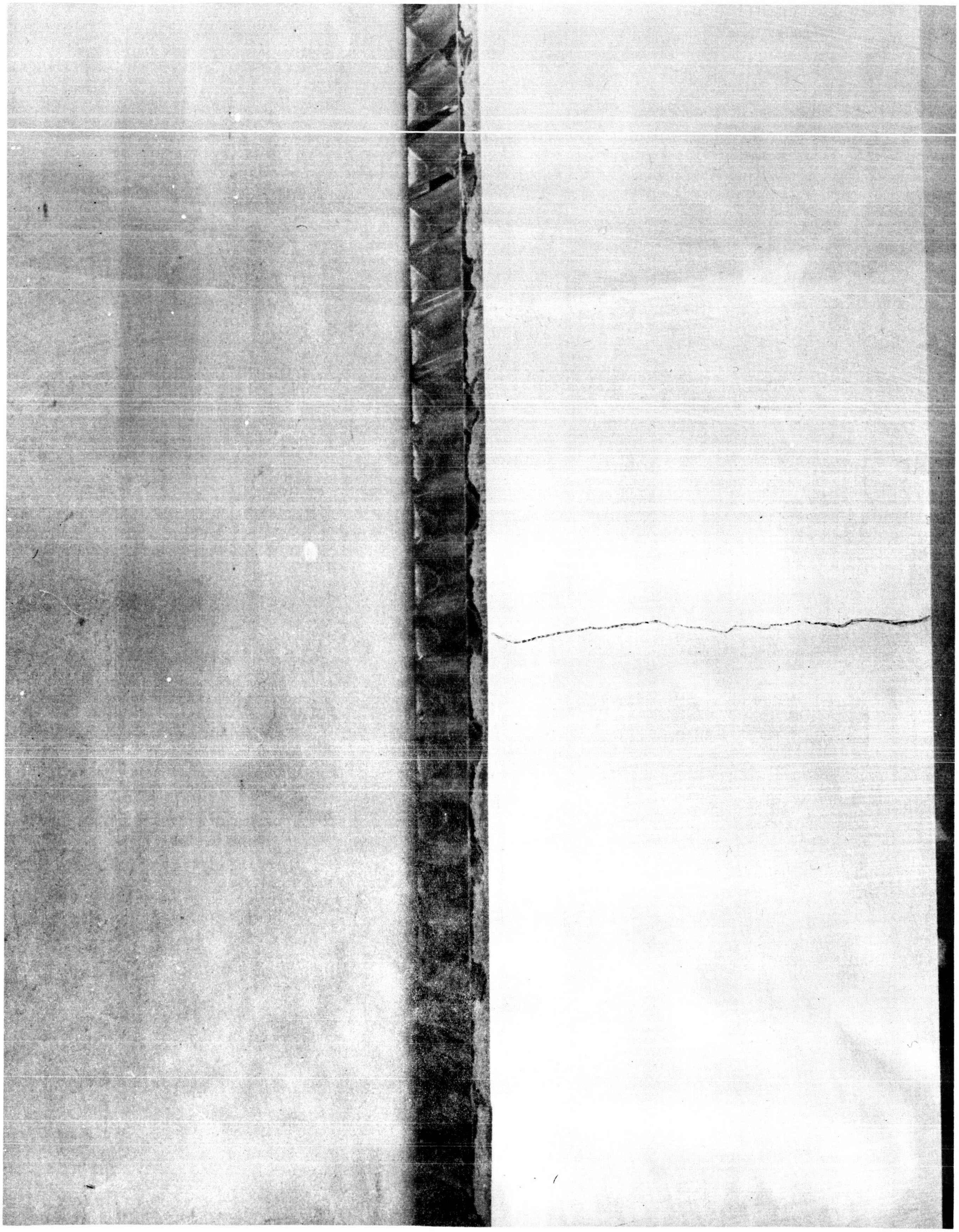
FLEXURE TEST OF HEAT SHIELD SECTION*

Dial Gage	Dial Gage	Load Lbs.	Deflectometer	Midpoint Deflection With Respect To Load Points	
.0105	.012	100	.0104		
.0185	.02	200	.0195		
.026	.027	300	.0274		
.033	.034	400	.0357		
.0405	.0405	500	.0440		
.047	.047	600	.0524		
.054	.054	700	.06		
.061	.061	800	.0688		
.0685	.0685	900	.0784		
.076	.075	1000	.0875		
.093	.096	.250	.09		
.1085	.1065	1310	.122	.0145 (.122 - .1075) for 7" span	Failure of M-31 occurred at this point. Failure consisted of a slight crack extending the full panel width and through the entire depth of the M-31. Separation of the M-31 from the panel facing did not occur.

*Ref: Aeronca Test Report TR-50-63





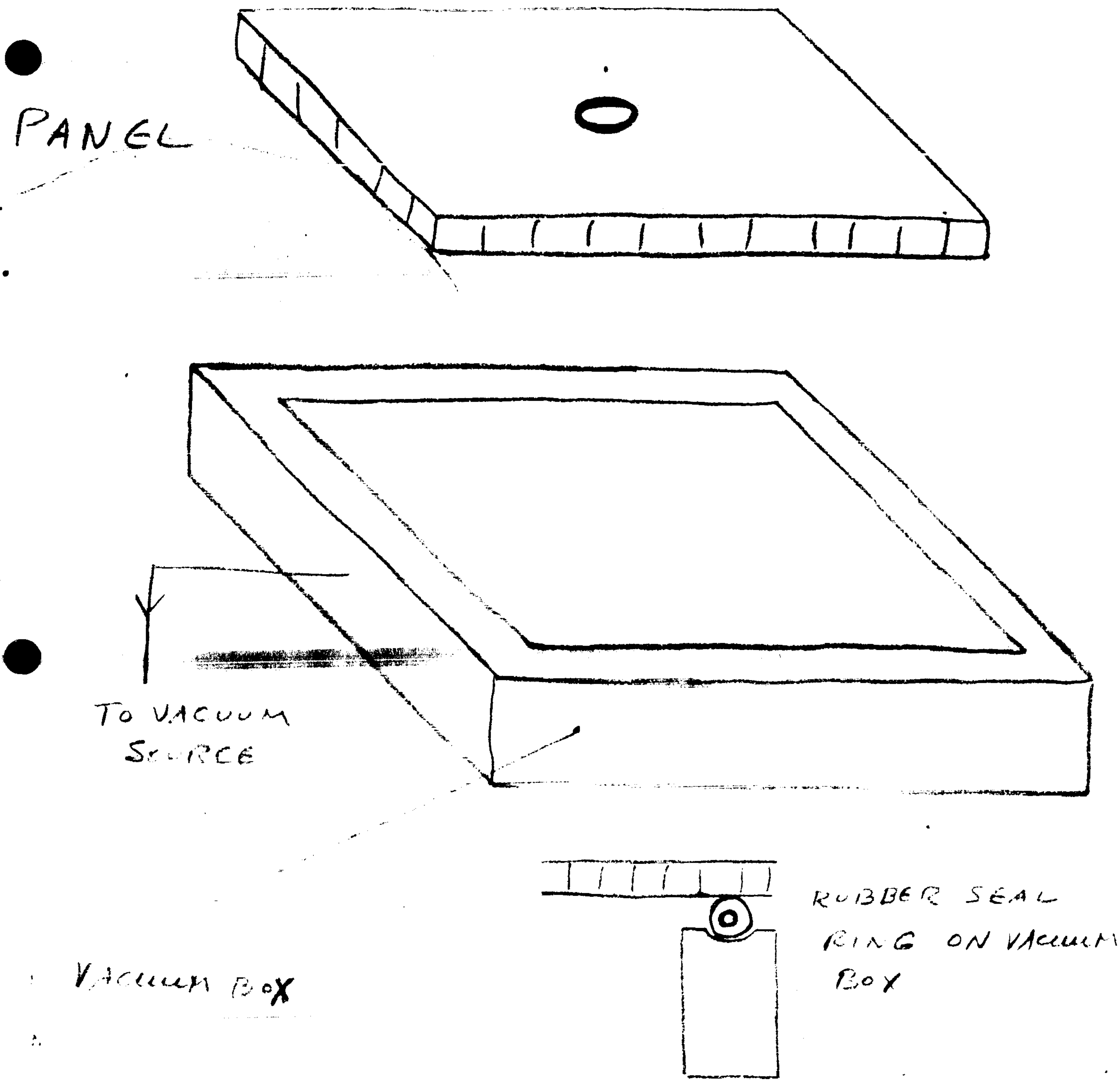


TEST PANEL FABRICATION AND TEST PLAN

Test panels 20"x30"x1.02" thick consisting of Type 4-15 core 1.0" thick and 0.010 facings both of PH 15-7 Mo alloy silver brazed are currently being fabricated per attached schedule.

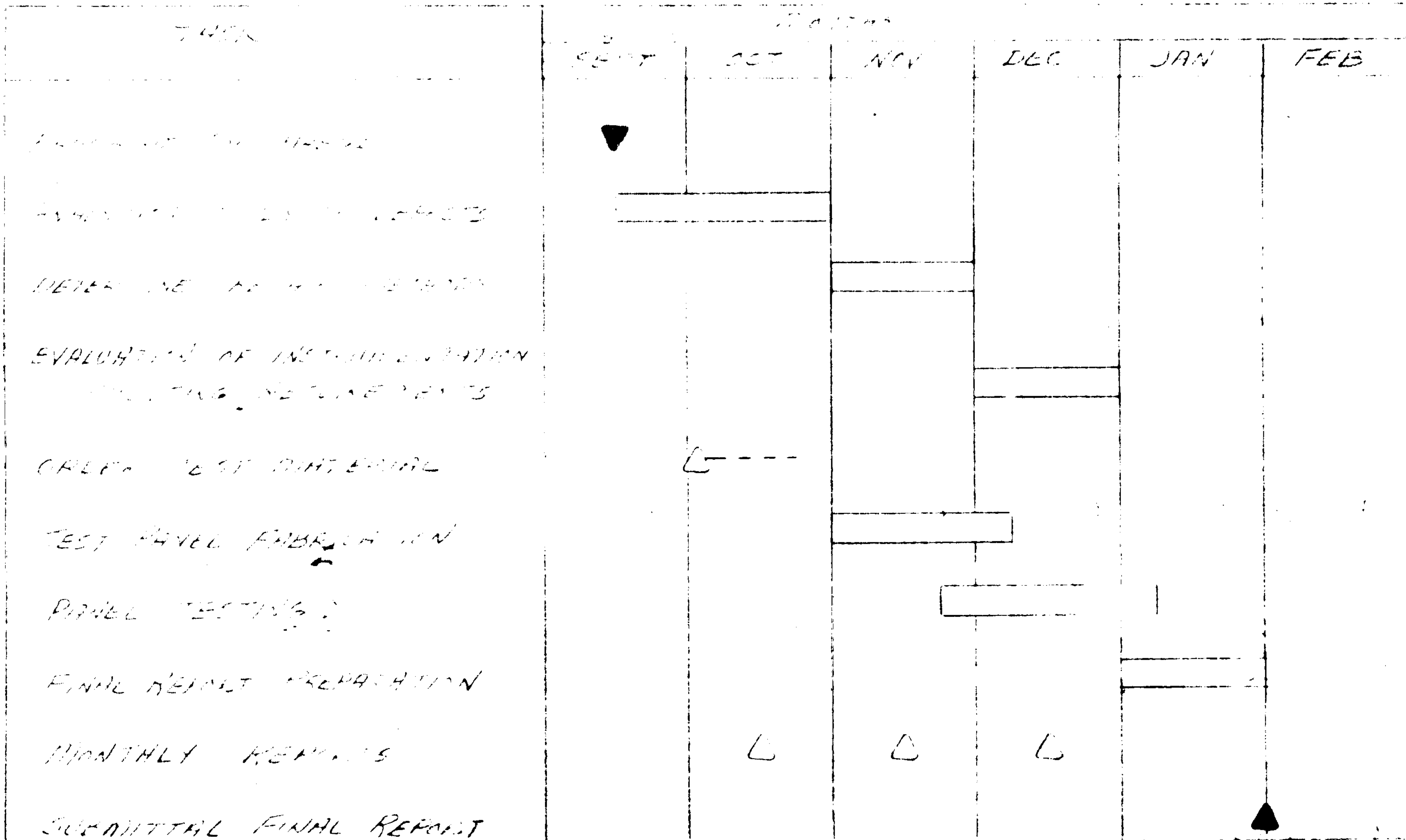
The test panels containing holes representative of the largest size instrumentation mounting requirements 3/4" diameter and about 2" diameter will be subjected to a bending load by means of a partial pressure applied to the panel via a vacuum box fixture (Fig. 11). This type of loading and panel support simulates [redacted] mounting and air loads and is expected to be less costly than the simple beam type bending fixture initially proposed. Stress concentrations around the openings will be determined using stresscoat while the magnitude of the stresses will be determined with strain gages. The tests will be conducted at room temperatures.

REVISIONS:



TEST PANEL BENDING METHOD
FIGURE 11

PROGRAM SCHEDULE



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